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Research Notes – An Introduction to Openness and Evolvability Assessment

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ABSTRACT

These Research Notes form part of a series of notes extracted from work undertaken by Innovation Science in the establishment of Openness and Evolvability assessment Methods and Processes. This set of Research Notes focusses on an introduction to the assessment of Openness. This work was undertaken from the late 1990s to 2007 and focussed on the application to Submarine Combat Systems.

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1. Introduction

These Research Notes have been extracted from work undertaken by Innovation Science under contract to Defence Science and Technology Group during the period from the late 1990s until early 2007.

In entirety the Research Notes form a subset of the overall assessment Methodology and Processes developed to assess system level Openness and Evolvability.

The Research Notes within this report focus on an introduction to the assessment of Openness.

2. What are Openness, Evolvability and Open Systems

Openness: The extent to which components (third party and integrator) can be independently integrated, removed or replaced without adverse impact on the existing system.

Evolvability: The ease with which a system or component can be modified to take advantage of new software or hardware technologies.

Open System: A collection of well-bounded, interacting components (software, hardware and/or human) with well-defined, published and configuration-managed interfaces, interconnected by well-defined, published and configuration-managed infrastructures, and where sufficient procedures and policies govern the system to ensure components can be independently added, removed or replaced without eroding the system architecture.

3. Scope Selection

An evaluation of openness can be applied at many levels. The focus could be on the ability for different federated systems to be interconnected to form a system of systems. Or, perhaps the focus could be on the ability for different vendors to be able to provide small functional elements within a single application. The scope of the openness requirement will alter the importance of different business and technical characteristics that combine to achieve an open solution.

The complexity of most large-scale systems of systems is such that realistic functional boundaries are defined to limit the scope of the system-of-systems architecture. The system of systems architect essentially delegates responsibility for anything that fits entirely within one of these functional boundaries. The boundaries defined by the architecture indicate the architecture's granularity. Attempting to micro manage the solution by defining large numbers of very small granules is fraught with risk.

The same principle applies to the architecture of a software application. An appropriate granularity is selected to represent the architecture of the software application, but the responsibility for anything that exists exclusively within a single boundary is delegated to a software developer. It may still be appropriate to ensure the provision of functionality within the application can be achieved in an open and evolvable manner. Hence, an openness assessment of an application will focus more on the infrastructures and processes defined to support third-party provision and integration of functionality directly into the application.

3.1 Granularity Layers

It is up to the assessor to determine an appropriate number of layers to conceptualise the target solution. The selection of names for each of these layers is also a point of personal preference. However, for the purposes of examples in this document, we have chosen six hierarchical layers of granularity named as follows:

Module — The smallest unit of functionality that is to be considered as a black-box within a host Application. Module openness is not a valid assessment criteria.

Application — A software program or hardware unit that comprises a collection of interacting modules or related functionality that can be managed as a single entity, if required. Multiple applications may be combined to form a Subsystem.

Subsystem — A group of related and interacting Applications that combine to form a capability unit within a wider System.

System — A group of Subsystems that combine and interact with one another to offer a coherent operational capability.

System of Systems —A heterogeneous group of loosely related and largely independently evolved Systems that combine through the sharing of data or control to provide a multi-discipline solution.

Enterprise — The collection of Systems and Systems of Systems throughout the organisation that share data, control and/or component capabilities.

4. Technology Readiness Level

Assessing the openness of a system that is at a planning stage requires an entirely different focus than an assessment of a mature, deployed system. Hence, the technology readiness concept (or a variation thereof) offers a way to vary the range of questions used to assess openness to best suit the target system's level of maturity.

5. Assessment Focus

There are six assessment categories within the openness and evolvability assessment. These are:

- Business Processes
- Legal Framework
- Engineering Processes
- Architecture
- Infrastructures
- Interfaces

Process characteristics look at how well the documented processes and procedures support the system's acquisition, development and integration activities. Implementation characteristics look at the resulting design and realization of the system itself.

In addition to these six categories, assessment topics specifically addressing standards and documentation assessment are also defined. These additional topics are referenced by several of the assessment categories. A synopsis of each assessment category is provided in the following sections.

5.1 Business Process

Focusing primarily on the acquisition organisation or the part of the project team that is tasked to oversee the acquisition and development of the system, the Acquisition Process focus evaluates risks to openness associated with the policies and procedures that are defined for the acquisition role.

- Identification of key interfaces – evolution planning
- Personnel training in open systems
- Defined responsibilities
- Conflict of Interest avoidance through Independence between roles

- Migration processes
- Compliance to documented processes
- Periodic Standards Review [Obsolescence/Emergence]
- Acquisition methodology.

5.2 Legal Framework

In order to successfully utilise multiple component vendors in an independent manner (i.e. in isolation of the original system prime), the system must be governed by an appropriately constructed legal framework. The Legal Framework focus evaluates the completeness and sufficiency of such a framework.

5.3 Engineering Process

Processes and policies directly associated with the system development and integration fall into the Engineering Process focus. These include:

- Configuration management
- Independent Verification and Validation
- Independence of responsibilities
- Intellectual Property management.

5.4 Architecture

An open system requires a system architecture to be well defined and managed throughout the life-cycle. The Architecture assessment foci evaluate architectural characteristics that influence openness such as:

- Quality and completeness of architecture documentation
- Consistency amongst architecture documentation
- Configuration management of the architecture documentation
- Dissemination techniques in use (may be a development process characteristic)
- Granularity of the architecture (size of functional blocks)
- Modularity (cohesion and coupling)
- Support for multiple customers/deployments.

5.5 Interfaces

Interfaces define a granule's externally visible boundary to which other granules can connect to exchange data and/or instructions for control. For the purposes of the Openness Assessment, an Interface does not include the infrastructure necessary to facilitate the transport of data between granules.

- Completeness of interface definitions (including definitions for all externally visible interfaces along with completeness of each of those definitions) — include performance constraints/requirements, units of measure, context metadata
- Availability of interfaces to third-parties
- Custodianship
- Configuration management of interfaces
- Documentation quality
- Reference implementations/Test Harnesses for use by third-parties
- Extensibility — ability for additional subsystems to connect to interface.

5.6 Infrastructures

An Infrastructure defines the set of standards that combine to enable the transport of data between interfaces.

- Completeness of infrastructure definitions
- Standards
- Availability of definition to third-parties
- Custodianship
- Reference implementations
- Performance/Scalability of infrastructure
- Documentation quality
- Configuration Management.

6. Assessment Preparation Steps

6.1 Identify Architecture

Obtain architecture representations. These should be at least functional and physical representations. In relation to the DoDAF (or similar frameworks), the minimum views should be:

- OV-2 (Operational Node Connectivity Description)
- OV-3 (Operational Information Exchange Matrix)
- SV-1 (Systems Interface Description)
- TV-1 (Technical Standards Profile).

Note that there is no requirement for architectures to be presented using representations discussed in DoDAF, MoDAF, DAF, etc. The architectural views listed above are included for guidance only. The primary aim for gathering architecture representations is to allow the assessor to understand the architect's intention regarding the system's granularity and couplings.

6.2 Establish granule boundaries

An architecture's granule boundaries should be identifiable from the available architecture documentation. However, care needs to be taken to ensure the scope of the documentation corresponds with the layer of interest for the purposes of assessment.

This assessment uses the terms, "granule" and "granularity" intentionally to avoid connotations otherwise associated with commonly used terms such as "module" and "component".

The term, "granule" is used within this assessment to represent a collection of closely related functionality, within which the architect is willing to consider beyond the scope of management at the architectural level. In other words, the contents of a granule can be considered a "black-box" for the purposes of the architecture. There should be no need to know anything about the internal construction or workings of a granule other than its functional, physical and performance characteristics that affect the ability for other granules to connect to and interoperate with the granule.

Well defined evolution plans will generally outline the functional and physical boundaries that best align with the future goals of the system. It is conceivable that preferred granule boundaries will not align with current granule boundaries. However, internal module boundaries may remain the same. This would be evident in a system containing a relatively large granule comprising a large number of modules provided by a single vendor, where the future evolution of the system would ideally see the large granule be divided into several smaller granules.

Establishing an architecture's granule boundaries results in a "box and line" diagram illustrating groups of functionality that are considered individual granules, along with indications of any communications that occur between those granules.

6.3 Isolate Infrastructures

Determine the sets of standards that combine to form each well-bounded shared infrastructure. An infrastructure does not include any interfaces or subsystem components, but provides the means to glue subsystems together so that they can interoperate via their interfaces. Architectures may comprise several distinct infrastructures. For example, if part of the system of systems involves the distribution of real-time data, the infrastructure used to facilitate real-time data distribution is likely to be entirely different to the infrastructure used to distribute ad-hoc client/server database requests.

7. Assessment Overview

7.1 Assessment Flowcharts

Each assessment category is accompanied by at least one flowchart that guides the assessor through the set of questions associated with the assessment topic. The sequential flow implied by each flowchart suggests it is possible to short-cut the evaluation process if a definite 'score' is awarded without navigating every question in the entire flowchart. The 'short-cut' representation is primarily intended to reduce the visual complexity of the flowcharts.

When assessing openness and evolvability, it is recommended that an assessment report be produced that identifies the risks to openness that are believed to exist within the solution. In order to achieve a comprehensive set of risks, the assessment for each category should not terminate when a 'short-cut' score is awarded.

7.2 Scoring

Each of the six assessment categories group a set of questions that enable the derivation of a category score. The score is an ordinal value that represents how well the solution meets the associated criteria believed necessary to achieve an open and evolvable system.

Each ordinal value also implies a level of risk that the system will not achieve an open an evolvable system. Hence, a colour is paired with each ordinal score to represent the risk level.

7.2.1 Comprehensive

Representing the ultimate target score for each assessment category, Comprehensive indicates the solution has extensively addressed all known issues within an associated assessment scope that could negatively affect the ability for the solution to be open and evolvable. Metrics resulting in a Comprehensive score represent Negligible Risk to the solution being open and evolvable.

7.2.2 Sufficient

An assessment that is considered Sufficient indicates that the solution substantially addresses all of the known issues (within the associated assessment scope) that could negatively affect the ability for the solution to be open and evolvable. A Slight Risk exists that long term openness and evolvability may be hindered because of a minor discrepancy or lack of process that could otherwise ensure openness.

7.2.3 Partial

While some aspects of the associated assessment topic positively contribute to an open and evolvable solution, Partial scores indicate that at least one aspect introduces a Substantial Risk that openness will not be achieved. A large number of openness and evolvability assessment metrics result in a Partial score. However, the level of effort required to resolve many of the offending issues can often be small — particularly if other aspects of the assessment topic are already adequately addressed.

7.2.4 Limited

A score of Limited indicates there is, at best, only a very small ability for the solution to support independent third-party integration. A Major Risk exists that openness and evolvability will not be achieved.

7.3 Reporting

The elementary result of the openness and evolvability assessment is a set of six scores that indicate the extent to which the candidate solution is considered open and evolvable in relation to the six major assessment categories. These scores provide only a coarse representation of a solution's openness and caution should be exercised before exhibiting the six scores in isolation of supporting evidence.

It is strongly suggested that any assessment be reported as a combination of the six category scores together with a synopsis of the identified risks (together with their impact on the overall openness score).

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